

NOTE:

The following seed proposal, “*Understanding Knowledge Acquisition and Transfer by Global Organizations engaged in Global Projects*”, was submitted to the Center for Integrated Facility Engineering (CIFE). The proposal was accepted and received \$20,000 of funding for the 2007-2008 academic year.

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CIFE Center for Integrated Facility Engineering · Stanford University

CIFE Seed Proposal Summary Page 2007–2008 Projects

Proposal Title: *Understanding Knowledge Acquisition and Transfer by Global Development, Construction and Engineering Firms*

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First Submission? **Yes** **If extension, project URL:** _____

Abstract (up to 150 words):

Studies of global projects in construction and other industries have focused on cross-cultural conflicts arising from project participants with different and often clashing values, norms, work practices and regulatory frameworks. However, global projects also offer enlarged information and knowledge bases from which providers can gain new knowledge, innovations and opportunities. Unfortunately, history shows many organizations fail to acquire, store and transfer knowledge from projects to their organization. They “reinvent the wheel” on each project, wasting both time and money. This research uses in-depth case studies to explore ways global engineers, contractors and developers currently acquire, store and transfer knowledge from global projects; and to identify which mechanisms best facilitate management and transfer of knowledge at various phases. Our long-term goal is to improve the understanding and practice of knowledge management for global firms in project-based industries like construction, addressing CIFE goals of improved performance and collaboration as firms expand globally.

1. MOTIVATING ENGINEERING/BUSINESS PROBLEM:

History shows that firms in project-based industries like construction continually repeat the same mistakes. They dash from one project to another without pausing to reflect and capture “lessons learned” from the problems and experiences encountered on past projects. Furthermore, project teams are seldom kept together even within a single organization, so they are often not privy to the more subtle or “tacit” knowledge developed in prior project teams about mistakes made, problems encountered, and subsequent lessons learned from previous project teams. They repeat the same or similar mistakes on their projects, causing the organization to spend time and money relearning solutions to problems that have already been identified and solved. The lack of time and resources dedicated to recognition, capture and sharing of knowledge from projects causes organizations to reinvent the wheel continually, wasting both time and money.

At the same time, organizations and their supply chains are expanding globally. With a billion more inhabitants of earth in the next decade (Sachs, 2004), developers, contractors, and engineers are working internationally to address a shortfall of approximately US\$3 trillion in basic infrastructure (ADB, 2005). Building this infrastructure both efficiently and sustainably will require drawing on lessons learned in the past both to meet the impending demand and to avoid making the same environmental, social and economic mistakes of the past on an even larger scale. Global developers, engineers and contractors engaged in building around the world encounter diverse teams and working locations that offer new and enlarged information and knowledge bases. Not only do firms need to document and share lessons learned within an organization, but they also need to acquire, integrate and share these lessons across the many kinds of firms in their global supply chain. This creates significant challenges. At the same time, it provides business opportunities for firms who are able to tackle these problems while working in diverse environments.

Previous studies of global projects in construction and other industry sectors have primarily focused on the cross-national problems (conflicts, cost and schedule overruns, quality and safety problems) that result from working globally in diverse teams and unfamiliar institutional environments (Orr, 2005; Mahalingam, 2005; Orr and Scott, 2007, Mahalingam et al, 2005). Far less attention has been paid to potential opportunities for cross-national knowledge sharing that flow from such projects. Developing residential, industrial and infrastructure projects globally exposes a firm to different settings that increase the flow of ideas, challenges and experiences to which it is exposed (Huber, 1991). This affords opportunities for firms to learn and gain new capabilities from both the projects and from one another (Barkema and Vermeulen, 1998).

In an ever more tightly interconnected world, there exists an enormous repertoire of lessons from which to draw. The urgent need for development and infrastructure combined with a past riddled with environmental, social and economic mistakes creates an urgent need to address the problems with sustainable solutions now. It requires us to have a commitment to learn from the past, share our knowledge and apply lessons learned on future projects. Developing global projects more efficiently and sustainably through enhanced knowledge sharing and innovation can enhance the economic well being of people, organizations and even nations, while contributing to advances in both knowledge and engineering-construction practice.

Objectives

We propose to conduct exploratory research on how global companies engaged in engineering and construction projects are able to *acquire, integrate and transfer* the knowledge gained from projects across their global operations. Our objectives are to:

- Enhance understanding of how institutional, cultural, geographical and work practice differences lead to the creation of new knowledge
- Identify both the conditions and social structures that facilitate or inhibit knowledge formalization and sharing on global projects
- Explore the ways in which global providers currently acquire, store and transfer knowledge from multi-participant projects in developing countries by examining organizational infrastructure, information technologies and managerial policies and practices
- Examine the effectiveness of alternative approaches in diffusing knowledge across a firm's projects and global supply chain

Our objectives respond to the stated CIFE goals of *schedule performance and cost conformance* by offering ideas to decrease repeated mistakes and the time to solve problems which reduce costs; *sustainability* by offering suggestions for global knowledge sharing from world-wide information bases of best practices; and *globalization* by focusing specifically on global projects and how cross-institutional differences can become objects of attention to facilitate the creation of new knowledge and innovations.

2. THEORETICAL AND PRACTICAL POINT OF DEPARTURE

The proposed research builds upon prior CIFE research by Tatum (CIFE TR078, TR081) on innovation processes in the AEC industry and on research by Taylor and Levitt on barriers to innovation in networks of AEC firms (Taylor et al, 2006). Drawing from institutional theory and the global business literature, it also builds on research in the Collaboratory for Research on Global Projects (CRGP) on the “unforeseen transaction costs” (Orr, 2005; Mahalingam, 2005) that flow from cross-national cultural values and institutional differences on global projects. However, the proposed research departs from previous CRGP studies that focused on costs. Instead it seeks to identify the silver lining to the dark cloud of cross-cultural global projects — new opportunities for knowledge acquisition and sharing that can result from these institutional intersections.

The research will examine, and build upon, organizational learning and knowledge management within the engineering and construction industries. These industries are particularly apt to understand that incomplete transfer of knowledge can cause unnecessary rework and delay (Paulson, 1976; Jin and Levitt, 1996). Despite the fact that they understand this, previous studies have shown that few developers, constructors or engineering consultants have formal procedures to capture and reuse information from past experiences (Harris, 1995). Even though organizations have the desire and need to learn from experience, they give reasons of lack of time, money and increased pressure of upcoming work for not capturing and sharing knowledge (Scott and Harris, 1998). While the AEC industry continues to acknowledge the need for information gathering and knowledge sharing, it continues to operate in the same mode, despite the impact that lost knowledge can have on a project's duration and cost (Ibrahim, 2005).

Our research aims to build upon Nissen’s (2006) model of the multi-dimensional aspects of knowledge flow (See Figure 1). It seeks to examine the flow of knowledge based on knowledge type (y axis), the phase within the knowledge lifecycle (z axis), and the “reach” of the knowledge as it spreads from individual to group, project team, organization and beyond (x axis). Additionally, we aim to study the various managerial mechanisms, incentives and structures (designated by stars added on the diagram) that are in place to facilitate knowledge flow through its lifecycle and reach.

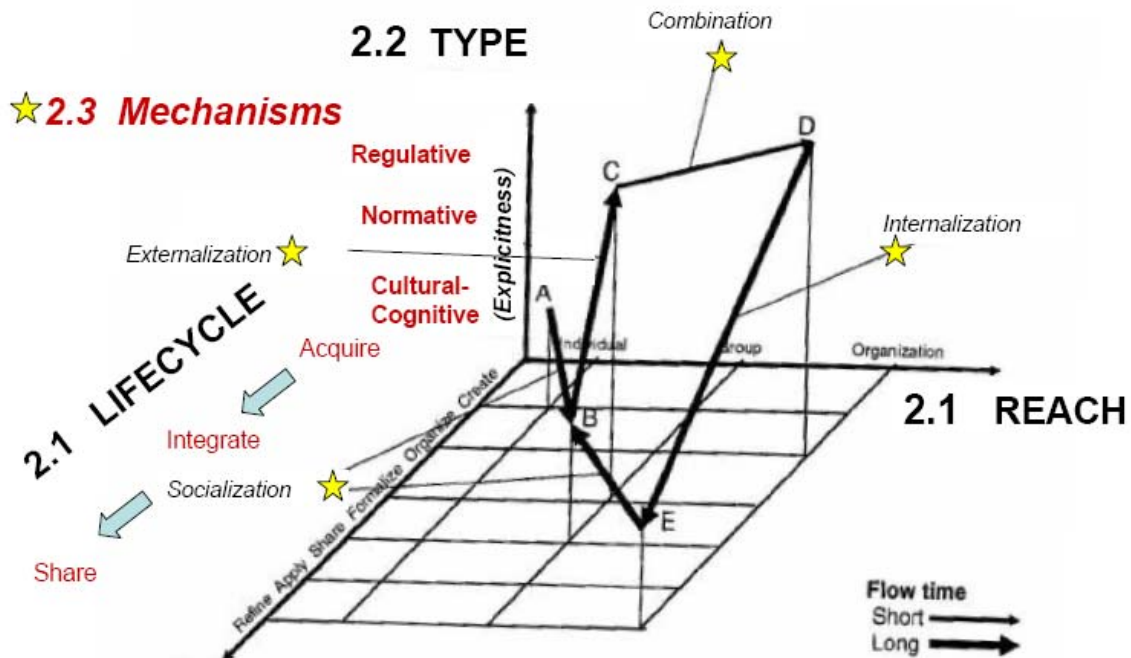


Figure 1
 “Multi-Dimensional Knowledge Flow”
 Adapted from (Nissen 2006)

2.1. KNOWLEDGE LIFECYCLE AND REACH

We will elaborate on the lifecycle activities of acquisition, integration and transfer of knowledge, intertwining it with the reach of knowledge as it expands from the individuals and teams engaged in the engineering and construction of global projects and spreads across their global firms and global supply chains.

Knowledge Acquisition

Intuition and the literature inform us that global projects expose firms to a diversity of environments, experiences, challenges and cues from which they can learn and exploit lessons (Miller & Chen, 1996; Barkema et al, 1996). However, gaining new knowledge requires that the information not only be available, but also requires organizations to actively search for it and realize its potential value. The ability to do this will often depend on the “absorptive capacity”, or the prior knowledge and exposure of the project team or firm (Cohen & Levinthal, 1990). Global projects create the additional challenge of “double layered acculturation,” requiring adjustment to both the different national and corporate cultures and institutions.

Knowledge Integration

The knowledge-based theory of the firm states that organizational knowledge is a resource with at least the same level of importance as capital (Grant, 1996). However, if knowledge is not accessible to employees within an organization when and where it is needed, it adds little value. Global firms engaged in multiple projects across the world are interested in achieving higher performance by integrating individual's and project team's specialized knowledge and lessons and storing them in such a way that they are later accessible and retrievable by other firm members.

Knowledge Transfer

In addition to the level of knowledge inventory and availability, the flow and transfer of knowledge is critical to an organization's success. The theory of knowledge conversion (Nonaka, 1994) assumes that knowledge is created or converted through a spiral-like process involving four steps (seen in Figure 1):

- Socialization: knowledge transfer (typically involving tacit knowledge) through shared experiences such as mentoring or on-the-job training;
- Externalization: knowledge transfer through questioning or reflection on projects (ie. post project mortems) often used to transform tacit knowledge into more explicit knowledge ;
- Combination: transfer of knowledge (often explicit) by integrating the knowledge through meetings or formal information processing and technology mechanisms;
- Internalization: knowledge transfer from explicit to tacit, requiring members not only to be aware that the knowledge is available organizationally, but also to internalize the knowledge by learning it;

The flow of knowledge on and from global projects will allow it to be used and applied to future projects as its reach "amplifies" from the individual to the project team and eventually the overall organization (Nonaka, 1995). Kogut and Zander (2003) argue that successful multinational corporations will arise out of their superior ability to integrate and transfer this knowledge efficiently across borders.

2.2. KNOWLEDGE TYPE

The type of knowledge is integral to how knowledge is able to flow. In Nissen's diagram, the y axis designates the explicitness of the knowledge type. Our research will focus on institutional knowledge and learning involved in global projects. We plan to modify the y axis of this diagram (as shown) with our findings based on the institutional element and its degree of explicitness (ranging from tacit to explicit).

Institutional learning concerns knowledge of the social, cultural and legal frameworks that undergird social life in different societies. In a mono-cultural context these frameworks are stable and constitute the unnoticed background of social behavior. However, in situations involving multiple people from diverse organizations and countries working in unfamiliar locales, institutional differences loom large, making institutional learning and integration of these lessons critical to project success.

Following Scott (2001: 48), we define institutions broadly to include "regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life." In the context of global projects:

- *Regulative elements* include the formal machinery of governance: laws, rules, surveillance, sanctions and incentives. These elements are more easily observed, coded and more readily manipulated.
- *Normative elements* focus primarily on the obligatory dimensions of social life and stress shared values and norms and interpersonal expectations. Corporate cultures, conventional work practices and professional roles and standards are examples of normative elements in global projects.
- *Cultural-cognitive elements* tap into a deeper layer that includes widely-shared beliefs about the nature of the world (cultural frames) and cause-effect relations (social logics). The beliefs are socially constructed symbolic representations that provide templates for framing individual perceptions and decisions. Hofstede (1991) has identified a useful set of dimensions for assessing these elements.

As noted, regulative elements are more easily learned; they tend to be *explicit* and are therefore more visible and more easily captured and shared in published information and available from consultants. Normative elements are more difficult to learn, as they are encoded into the behavior of the people in the local context and in the cultural features of companies and work groups. Only sustained, interpersonal exchanges and prolonged exposure can uncover these differences. Most difficult to learn are the cultural-cognitive elements—elements that are more likely to be *tacit* and taken-for-granted by all parties—and require self-conscious and disciplined attention to differences to identify, comprehend and address.

Ideally, when such differences create “institutional exceptions” (Orr and Scott, 2007), they are no longer ignored or suppressed but become the subject of attention and of sense-making activities. We will focus on conditions under which institutional differences are recognized and become the subject of active learning efforts. Building on related research (Mahalingam & Levitt, 2004), we will also study the role of freelance expatriates—employed by both entrant project companies and host country companies and governmental agencies—who have been shown to play a critical role in brokering institutional differences across firms.

2.3. MECHANISMS

The firm is a social community which utilizes mechanisms to create and transform knowledge into economically rewarded products and services (Kogut & Zander, 2003). Global firms can have a particular advantage due to the new cues and challenges from their experiences which create learning opportunities from each market entered. Clearly, some firms are better at this than others. Our research seeks to explore formal and informal managerial and organizational mechanisms and controls (Turner & Makhija, 2006) used by developers, construction and engineering firms to facilitate knowledge flow across a project and organization. We will be cognizant of the types of mechanisms and structures used through each phase of the knowledge conversion process designated by the stars shown in Figure 1.

Knowledge Mechanisms on Global Projects

Global projects are often large and require the collaboration of many participants. We, therefore, plan to gather information not only on the organization but also on specific projects, using knowledge sharing examples to understand how knowledge is acquired

and transferred across project, company and country lines. We believe the acquisition and sharing of knowledge on global projects will be based on a number of factors including:

- Type of firm and phase of involvement, being attentive to the level of embeddedness of firms in the local environment (Orr, 2005)
- Type of contractual agreement (equity joint-ventures tend to ease knowledge transfer) (Mowery, Oxley & Silverman 1996)
- Absorptive capacity of the firm (Cohen & Levinthal, 1990) and experience in related areas (Barkema et al, 1996)
- Transparency and receptivity to learning of the firm (Hamel, 1991)
- Goals and objectives of the firm and the partners within the alliance (attending to the relationship between aspirations and observable outcomes (Levitt & March, 1988))
- Mechanisms used to influence communication between each other
- Structures set up for interaction among firms and with the host country.

Knowledge Integration & Transfer Mechanisms within the Firm

Managers are realizing the need to develop techniques and practices to facilitate knowledge flow within their companies by building knowledge databases that systematically and routinely transfer best practices and otherwise create a foundation for a knowledge based company (Ball et al, 2006). We plan to study both formal and informal organizational and managerial mechanisms to integrate and transfer knowledge gained from development, construction and engineering projects across global firms.

Formal mechanisms include processes, procedures, standards, templates, methodologies, technical support, discussion forums, etc. Information and communication technology can help to facilitate the formal integration of knowledge. But it is insufficient as a complete knowledge management system because people, not technology are central to the flow of tacit knowledge (Nissan, 2006). For example, in the visualization of knowledge conversion shown in Figure 1, explicit knowledge can be transferred and integrated through “Combination” which can include formal computer-based knowledge platforms. However, “Socialization”, or the transfer of tacit knowledge, often requires people to transfer tacit knowledge directly to one another. This can require formal training or mentoring sessions. We also believe that organizational incentive systems such as performance reviews, raises or special recognition, and social rewards such as increases in status within communicates of practice may need to be in place to encourage the flow of knowledge through a firm (Appleyard, 1996).

Informal mechanisms can include social processes and procedures such as on-the-job training or informal meetings to discuss projects and lessons learned. A study by Nonaka (1994) found that many individuals seek knowledge from individual experts on a personal basis. Many companies continue to rely almost exclusively on informal social interactions to facilitate relationships amongst the employees and gain an understanding of who knows what. Contrasting the formal mechanisms discussed above, informal mechanisms may rely on meetings for knowledge “Combination” and then rely on individuals to seek guidance from others for “Socialization” when they uncover situations that need specialized knowledge.

We anticipate encountering a wide range of organizational structures and managerial practices and mechanisms intended to facilitate knowledge flows within the firm. We aim

to learn more about: the benefits and barriers associate with each type; how they are linked to the corporate culture and structure; and whether, and what kinds of, incentives are needed to encourage employees to take the extra effort and risk required to share knowledge.

The institutional factors that can affect project success are both numerous and complex. Recognizing this complexity, we propose exploratory research to allow us to identify varying practices among companies. We will focus, in particular, on the interactions of different (1) phases of knowledge flow; (2) mechanisms of knowledge management; and (3) types of knowledge. These will allow us to examine which mechanisms and approaches are more or less useful for managing different types of knowledge at different phases in knowledge flow and conversion (see Figure 1).

3. METHODS

We plan to conduct exploratory research through case studies of global firms involved in global projects for this early-stage research in this area. We selected the case-based methodology because it provides a level of in-depth analysis that more general survey methods neglect and thus offers the prospect of rich, new insights (Eisenhardt, 1989; Yin, 2003). In addition, because it responds to the question of “How?” it will allow us to focus on organizational and institutional knowledge flow processes that occur naturally. After an extensive literature review, data will be gathered through collection of documents, interviews and observations from participating firms.

Case Studies

Cases will be selected to allow for comparisons that contribute to the building of theory (Yin 1984, 2003; Eisenhardt 1989). We intend to study three different firm types (developers, contractors and engineers) in order to observe different organizational structures and roles across a project’s lifecycle that enable different types of knowledge flows, recognizing that the firm type often determines the level of embeddedness an organization or project team has in the local institutions (Orr, 2005). The level of embeddedness and engagement with different types of institutions on a project is expected to have a significant affect on their learning processes. Developers and Contractors tend to be deeply embedded in the local context at varying times whereas Engineering Consultants tend to face medium to high levels of embeddedness (Orr, 2005). For instance, Developers are concerned with the entire project life-cycle, working with a variety of people from the conceptual stages through operation of the project. They often engage with local partners and rely on these local contacts to provide recommendations and advice for successful project development. While the majority of decisions are decentralized, the large investments often require that the locus of control reside with a regional office. In contrast, Contractors commit teams and resources to a project full time throughout the construction of the project. The team members typically reside at the project location, separated physically from the organization’s offices. Due to the need for rapid responses on the project, they control the project directly with little interaction or connection to the main offices. Moreover, the large size and temporary nature of these projects requires Contractors to engage a complex team of locals, expatriates and outside consultants to help them manage the work. Engineering

Consultants, on the other hand, engage in an advisory capacity to assist the project sponsor throughout various stages of the project. They often work on multiple projects at once, frequently from their firm's offices, and can transfer methods, technologies and knowledge across both projects and organizations.

Additionally, we plan to engage firms who obtain at least 30% of their revenue from international work (based on ENR 2005 rankings) in order to ensure that global projects are a significant focus of their business. Using the well-respected case study approach advocated by Yin (1984, 2003), these firms will be selected to ensure both *literal replication* —i.e., having more than one firm of each type (e.g., engineer, contractor, developer) — as well as *theoretical replication* —i.e., firms believed to differ along key dimensions that are expected to impact their acquisition and transfer of knowledge (such as those that stress formal IT approaches versus those that stress informal community building approaches).

Data Collection and Analysis

All case studies will be conducted in company offices or on construction sites and will involve data collection through:

- *interviews* with key informants
- *observations* of project meetings and collaboration
- *collection of documents and secondary data related to specific examples of knowledge acquisition and sharing* from global projects, including specific knowledge type, and the structure, incentives and format in place to allow for the sharing of this knowledge
- *collection of documents related to company structure, experience, incentives and managerial mechanisms* that are in place to promote formal or informal knowledge management

Case collection and analysis will focus on identifying the type of knowledge gained on projects, identifying and describing how knowledge is shared, and the mechanisms used by companies to enable and encourage knowledge flows between projects and throughout global organizations. We will transcribe the interviews and then code and analyze our transcriptions using a grounded-theory-building approach (Eisenhardt, 1989).

Validation

From the results of our interviews and in-depth case studies, we will analyze and code the cases to expand upon existing organizational learning and knowledge management theory and attempt to build new theory about how institutional differences can create learning opportunities for global firms. We will engage in a process of coding that will attempt to show which organizational strategies are contingently successful in different kinds of work (e.g., engineering vs. construction) for: (a) Learning on Global Projects; and (b) Sharing Lessons and Knowledge from global projects across both the firm and global supply chain.

The number of cases will be limited; so traditional statistical analysis techniques such as regression or structured equation modeling are unlikely to yield useful insights. However, the case information will be detailed. Therefore, to maximize the rigor of our research, we plan to do a “Qualitative Comparative Analysis” (QCA), a novel technique for analyzing qualitative case-based data developed by Charles Ragin (1987, 2000) to test

or discern patterns using Boolean set algebra. Based on the PI's current experience with this approach, we believe that using QCA to analyze this set of cases will help to address and integrate many aspects of the cases to examine how the contextual pieces work together to produce specific outcomes (Ragin, 1987, 2000).

We plan to use specific narrative examples of knowledge collection and transfer (or the lack thereof) collected from case studies to illustrate and explain the mechanisms that facilitated or the barriers that blocked the flow of knowledge within a global project provider. Detailed stories —“thick narratives”— about, for example, how novel seismic engineering practices in San Francisco were adapted from Japan by ARUP, how knowledge about “green building” practices was transferred from Europe to the US, and how enterprise-wide project-inclusive knowledge platforms foster communication around the globe within Fluor, can help illustrate the contingent success of different approaches to knowledge acquisition, integration and diffusion in different contexts. In addition to helping identify the mechanisms and structure in place to facilitate knowledge transfer and flow, these “thick narratives” will also help us validate previous findings and theories of multi-dimensional knowledge flows and conversions conducted by Nonaka (1995, 1999) and Nissen (2006). We hope to extend these theories by focusing on the project-based industries of development, construction and engineering with a concentration on different types of institutional learning and knowledge encountered on global projects.

4. RELATIONSHIP TO CIFE GOALS

The proposed research has a broad reach across a number of CIFE's breakthrough business objectives for AEC organization performance.

Schedule and Cost Performance

The cost of continually repeating history —particularly a history riddled with failures—has enormous implications for the overall organization's duration and cost performance on projects. Mechanisms that facilitate knowledge flow and transfer within a company and across a global supply chain can help to lessen repeated mistakes, decrease the time to solve a particular problem or issue and, as a result, reduce costs.

Sustainability

With continued rapid population growth and increased urbanization, we have an opportunity to make positive strides in “building better” that can have significant impacts on the environment. Sustainability of the built environment is our shared global concern. Across the world, people have developed an enormous repertoire of experiences and knowledge to draw from in addressing this concern. Worldwide sharing of best practices, wherever they may have been discovered, is critical to addressing this concern rapidly.

Globalization

The research is specifically focused on the direct CIFE objective of how global companies find new opportunities for growth, knowledge and innovation from working in global markets together with other global providers. While previous studies have primarily focused on the costs and failures of working with different institutions on global projects, we seek to find out how these differences can become objects of attention and sense-making to create both new knowledge and innovations, and hence strategic advantages, in both their home and overseas markets for global firms.

Implementation / Internet Collaboration

This exploratory research seeks to identify some of the managerial mechanisms and organizational structures that facilitate knowledge flow within a global firm and across a global supply chain in order for later industry implementation. The research will collect data from companies that have both a formal knowledge platform through internet collaboration as well as companies that rely primarily on social networks for knowledge flow to better understand how these differences facilitate or block knowledge flow.

5. INDUSTRY INVOLVEMENT

We have received overwhelming support and endorsement of this proposal from both CIFE and CRGP members. We have currently requested and received letters of support and endorsement from all five companies (Fluor Corporation, Parsons Brinckerhoff Inc., Skanska AB, ARUP and Hatch Engineering) initially contacted regarding this study. Additionally, we conducted preliminary interviews with Skanska and Hatch and attended a seminar by John McQuary with Fluor at an SAPM short course, “Managing Global Initiatives” to obtain preliminary information on the topic. We hope to seek involvement of additional CIFE members interested in participating in this study.

We plan to hold a roundtable during and at the completion of our research to seek and integrate valuable feedback and insight from our industry collaborators and members. In addition, we will provide the involved participants with early results of the proposed research.

6. RESEARCH PLAN, SCHEDULE AND RISKS

Using VDT (SimVision) (Levitt et al, 2006) we developed what we believe is a feasible and effective work plan to accomplish our goals within the two year time period of this research effort. Figure 2 shows the sequence of tasks we have identified (yellow rectangles) and the assignments of tasks to team members (solid blue arrows indicate primary responsibility while dashed blue arrows indicate secondary responsibility).

2007 – 2008 Milestones:

1st Milestone (End of October 2007): Obtain IRB Human Subjects Approval (currently in review), Seek and Receive confirmations from organizations willing to participate, Hold preliminary conference calls/Working Session, Post Working Paper, Implement Project Website.

2nd Milestone (End of September 2008): Conduct Case Studies, Begin Coding to develop descriptive theory regarding the mechanisms that facilitate knowledge sharing, Identify examples that expand upon existing knowledge management and organizational learning frameworks.

2008-2009 Milestones:

3rd Milestone (End of December 2008): Code and Analyze Cases using QVC, Obtain any additional information from participants required to refine and validate the data

4th Milestone (End of September 2009): Refine Model and Theory, Produce final report and presentation, Hold Roundtable or meeting to discuss results with participants and CIFE members.

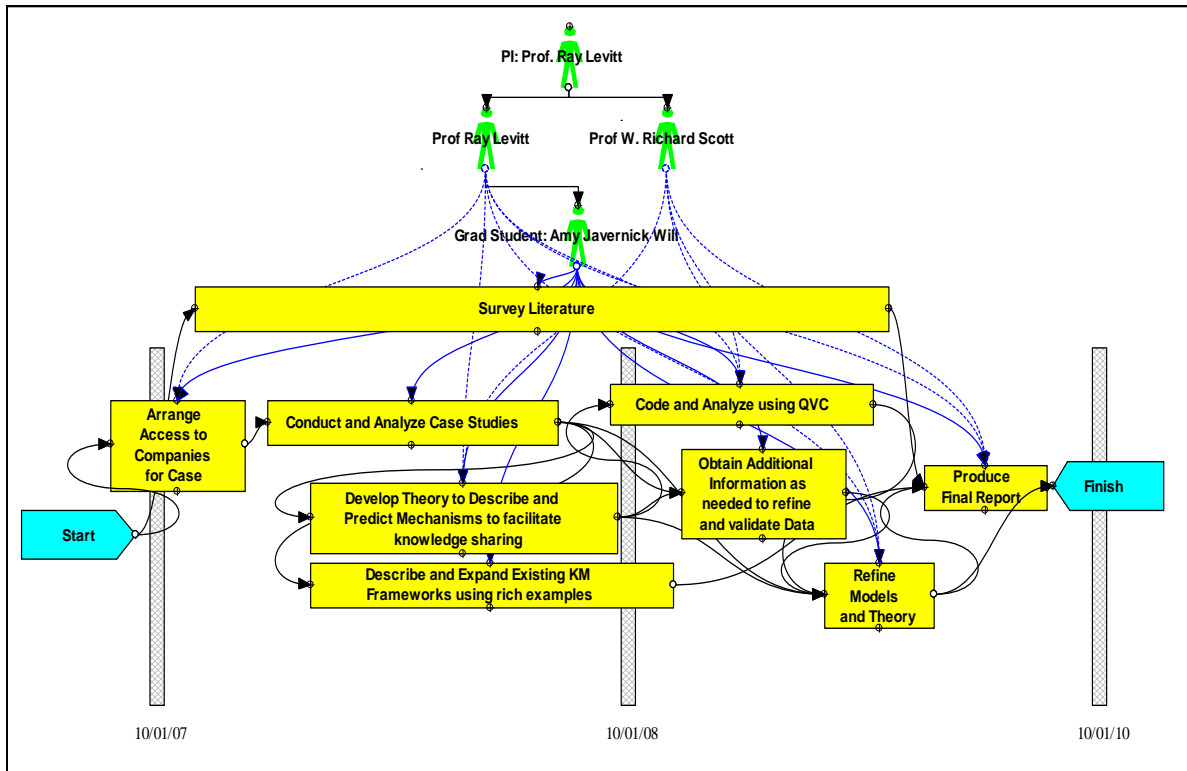


Figure 2: 2-Year Work Plan

7. NEXT STEPS

The first year of exploratory research for which we are currently seeking funding will lay the groundwork for future empirical research through case studies and surveys with a larger sample of firms that can ultimately provide stronger external validation of the mechanisms that help foster collaboration and knowledge flow among global projects.

We have submitted a proposal seeking alternative sources of funding for this project for year two and beyond through the National Science Foundation’s Civil Mechanical and Manufacturing Innovations (CMMI) and Office of International Science and Engineering programs (OISE); and we will be submitting a proposal to the US DoD Center for Edge Power later this year if the NSF proposal is not successful.

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